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AUTHOR McFadden, Charles
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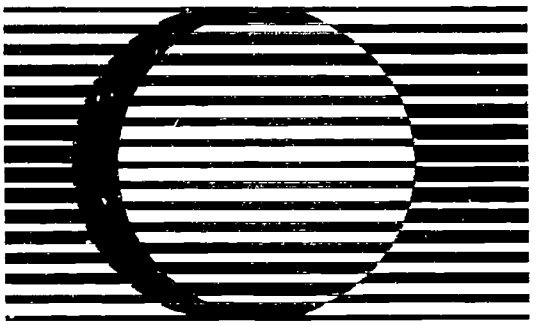
ABSTRACT

After several years of curriculum writing workshops and field-testing of draft materials, involving approximately 150 teachers, the SciencePlus program was implemented in Nova Scotia and New Brunswick between 1986 and 1991. SciencePlus programs provide a shift from an overwhelming emphasis on fact-recall testing to a predominate emphasis on testing for understanding of concepts and ideas. The SciencePlus program has been associated with a doubling of the frequency of hands-on practical activities. The paper describes the observational research carried out during the 1990-91 school year in grade 7, 8 and 9 science classrooms in New Brunswick and Nova Scotia. Sixty-three teachers from 25 randomly selected classrooms were observed on an unannounced drop-in basis for 165 lessons. During only 12.7 percent of the observed class time was whole class non-interactive teaching taking place, which was a decrease from the 35 percent level found in 1977. Students were found to be engaged in hands-on explorations during more than one-quarter of the lessons observed. Demonstrations were equally frequent and were usually conducted as part of a heuristic strategy, with extensive student input and guidance. Seventy-two percent of the class time was used for meaningful learning. The following improvements are needed: (1) greater use of cooperative learning; (2) a uniformly high rate of occurrence of hands-on, minds-on learning; (3) more student-initiated learning; and (4) more attention to science, technology, and society and the nature of science. (PR)



ATLANTIC SCIENCE
CURRICULUM PROJECT

# TEACHING SCIENCE PLUS: AN OBSERVATIONAL SURVEY

# TEACHING SCIENCEPLUS: AN OBSERVATIONAL SURVEY OF SCIENCE TEACHING IN NEW BRUNSWICK AND NOVA SCOTIA GRADES 7, 8 AND 9

(September 1990 to June 1991)

Research Report Number 5
Atlantic Science Curriculum Project

Author and principal investigator:
Charles McFadden
Professor of Education
The University of New Brunswick
Fredericton, NB Canada E3B 6A3
Phone: 506 453-3500
FAX: 505 453-3569



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**TEACHING SCIENCEPLUS: AN OBSERVATIONAL SURVEY OF SCIENCE TEACHING IN NEW BRUNSWICK AND NOVA SCOTIA GRADES 7, 8 & 9**

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**TEACHING SCIENCEPLUS: AN OBSERVATIONAL SURVEY OF SCIENCE TEACHING IN NEW BRUNSWICK AND NOVA SCOTIA GRADES 7, 8 & 9**

**REPORT AND RECOMMENDATIONS**

Observational research carried out by the author during the 1990-91 school year in grade 7, 8 and 9 science classrooms in New Brunswick and Nova Scotia adds to the evidence of substantial change in science teaching practices over the past decade. Prior evidence of change came from a survey questionnaire conducted in the spring of 1990 and reported by the author (McFadden 1990a, 1990b, 1991a). This change is associated with the development and introduction of the **SciencePlus** program. The introduction of this program followed several years of curriculum writing workshops and field-testing of draft materials, involving approximately 150 New Brunswick and Nova Scotia science teachers. The published version of **SciencePlus** was introduced into schools in Nova Scotia between 1986 and 1988 and in New Brunswick between 1989 and 1991.

In three papers published from 1978 to 1980, Roger Hacker and colleagues reported the results of their 1977-8 observational study of more than 100 lessons taught by 21 New Brunswick and Nova Scotia junior high science teachers. Their research provides a record of teaching practices prior to the advent of the Atlantic Science Curriculum Project and the development and introduction of the **SciencePlus** program. Classroom interactions associated with a didactic approach were observed in 1977-8 to occur twelve times as often as interactions associated with heuristic classroom strategies. Two-thirds of the teachers Roger Hacker and colleagues observed emphasized the acquisition of facts. Interaction between these teachers and their students was characterized by teacher statements of fact or principle and student requests for or confirmation of these statements. Very little variation was observed from one lesson to the next. (Hacker, Hefferman & Higgins, 1978; Hacker, Hawkes and Dryer, 1979; and Hacker, 1980)

Evidence consistent with this picture was provided by a survey conducted in the spring of 1977 as part of the formative evaluation that led to the establishment of the Atlantic Science Curriculum Project. Participation in the 1977 survey included 90% of the approximately 750 New Brunswick and Nova Scotia junior high science teachers. These teachers estimated that their students spent 35% of class time listening or taking notes compared to only 11% performing experiments and 3% in small group discussion. (McFadden, 1980).

The 1990 survey revealed that the introduction of the **SciencePlus** program was associated with a doubling of the frequency of hands-on practical activities, which are now featured in more than one of every four lessons. There has also apparently been a shift from an overwhelming emphasis on fact-recall testing to a predominate emphasis on testing for understanding of concepts and ideas.

The observational survey undertaken by the author during the 1990-91 school year has added to this evidence of change. During 1990-91, 63 teachers from 25 randomly selected schools in New Brunswick and Nova Scotia were observed. On an unannounced drop-in basis, this included 165 lessons. During only 12.7% of the observed class-time was whole class non-interactive teaching taking place (such as, for example, students taking notes or listening to the teacher, activities that teachers in 1977 estimated took up 35% of class time!). Students were found to be engaged in hands-on explorations during more than one-quarter of the lessons observed. Demonstrations were equally frequent and were usually conducted as part of a heuristic strategy, with extensive student input and guidance. (McFadden, 1991b)

In the 1990-91 observational survey, the average student was judged to be spending 72% of class time engaged in such meaningful learning activity as concept assimilation and/or using such higher intellectual skills as analysis, synthesis, evaluation and imagination. In making this judgement, time spent by students in taking notes, in the transition between learning activities and on their social agendas was not included as educationally meaningful. Meaningful learning was judged to occur during teacher interventions only if this intervention evidently elicited student thought or action. Account was also taken of the proportion of students at any time evidently disengaged from learning activity. In view of all this, the estimate of 72% meaningful student engagement during science classes appears to represent truly remarkable progress in science teaching.

During the 12.7% of class time that whole-class non-interactive teaching took place, the level of meaningful student engagement was judged to be only 46%. The level of engagement when students worked individually (20.6% of the time) was judged to be 68%. This less than average value reflected in part the fact that some students complete work before others and often remain idle while other students are still working. Meaningful engagement rose to 76% for the 48.0% of class time spent in whole-class interactive teaching and to 80% for the 18.7% of time spent in small group interaction.

Facilitation of concept understanding was emphasized by

teachers in 65% of the lessons observed and was given noticeable (i.e. recorded by the observer) attention during a full 88% of the 165 lessons witnessed. Critical thinking and imagination was the major emphasis in 10% of the lessons observed and was given attention in altogether 53% of them. Scientific skill development was emphasized in 10% and given attention during 58% of the lessons observed. During 52% of the lessons observed, students were also noticed to be engaged in expressing their ideas in their own words in complete sentences, either in writing or orally.

Thanks primarily to the frequent use of cooperative group learning, students were engaged in the development of their social skills during 42% of the observed lessons. At the same time, knowledge recall was given attention in only 27% of the lessons observed and was emphasized in only 6% of them. (A complete listing of all observed learning activities and how student engagement in them was categorized is included in Appendix I.)

23 of the observed lessons were conducted in French (French Immersion classes). The average student in these classes was observed to spend 74% of class time engaged in meaningful learning, nearly the same as that observed in classes conducted in English. The proportions of whole class interactive teaching, small group learning and individual student in-class work were also practically the same as in classes conducted in English. In other words, there was no apparent difference in the quality of science teaching and learning between classes conducted in French and in English.

While the results of the observational study are very positive, there is still room for significant improvement in the quality of student engagement in junior high science classrooms in New Brunswick and Nova Scotia. Advantageous on the whole would be (1) a greater proportion of class-time spent in cooperative group learning and (2) a uniformly high rate of occurrence of hands-on, minds-on learning.

Some of the teachers' high priority goals, as revealed in the 1990 survey, still, on the average, get inadequate classroom attention. There is need in most classrooms for more (1) student-initiated learning and (2) attention to the relation between science and technology, science and society and the nature of science.

Improvements can be made through (1) wider acquaintance with and emulation of the exemplary teaching that is occurring in most schools, (2) location of all science teaching in classrooms or laboratories equipped with flat top desks, available running water and storage space, (3) a higher

proportion of science teaching by teachers assigned on a continuing basis to teach mainly science and (4) a curriculum revision to include some of the STS units which appear in later editions of **SciencePlus**.

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**TEACHING SCIENCEPLUS: An Observational Study of Science Teaching in New Brunswick and Nova Scotia Grades 7, 8 and 9**

**TABULATED DATA**

**RESEARCH SAMPLE**

**Table 1. Participation Rate**

| | New Brunswick | Nova Scotia | Total |
|---|---|---|---|
| Number of randomly selected schools | 13 | 12 | 25 |
| Number of 7,8,9 science teachers in these schools | 39 | 45 | 84 |
| Teacher participation rate = Number observed/ (Number observed +number declined) | 31/33 (94%) | 32/37 (86%) | 63/70 (90%) |
| Inclusiveness of teacher participation = Number observed/ Number of teachers | 31/39 (79%) | 32/45 (71%) | 63/84 (75%) |
| Inclusiveness of science class participation = Number of classes taught by observed teachers/ total number of classes taught by science teachers in schools visited | 75/85 (88%) | 111/131 (85%) | 186/216 (86%) |

**Comments** The twenty five randomly selected schools that participated in this research represent approximately ten percent of the nearly 250 schools in New Brunswick and Nova Scotia that include one or more of grades 7, 8 and 9. Access was gained to 86% of the science classes in these schools. Results of this research, therefore, can be taken to be reasonably indicative of the teaching practices of New Brunswick and Nova Scotia junior high science teachers.

**Table 2. Observations**

| | New Brunswick | Nova Scotia | Total |
|---|---|---|---|
| Schools visited | 13 | 12 | 25 |
| Teachers observed | 31 | 32 | 63 |
| Number of class periods observed | 84 | 81 | 165 |

**Comments** By mutual agreement between the author and the participating teachers, visits to schools and classes were on an unannounced, drop-in basis. Therefore, the classes observed are considered to be representative of the totality of grade 7, 8 and 9 science teaching. In the judgement of the author and the participating teachers, the presence of the author in classrooms, when it had an impact, was just as often the occasion of less responsive or disruptive student behaviour as it was a cause for greater teacher-student engagement.

## CLASSROOM INTERACTION

**Table 3. Time Spent in Various Forms of Classroom Interaction**

| Interaction | New Brunswick (min.) | % | Nova Scotia (min.) | % | Total (min.) | % |
|---|---|---|---|---|---|---|
| Whole class non interactive | 445 | 13.7 | 365 | 11.7 | 810 | 12.7 |
| Whole class interactive | 1399 | 43.1 | 1654 | 53.1 | 3053 | 48.0 |
| Individual student work | 727 | 22.4 | 581 | 18.7 | 1308 | 20.6 |
| Small group activity | 678 | 20.9 | 512 | 16.5 | 1190 | 18.7 |
| TOTAL | 3249 minutes /84 periods = 38.7 min/class | | 3112 minutes /81 periods = 38.4 min/class | | 6361 minutes /165 periods = 38.6 min/class | |

**Comments** In both New Brunswick and Nova Scotia it is the usual administrative practice in grades 7, 8 and 9 to have students proceed from one class to the next without a formal break. The length of a class period was therefore taken as the time from the initiation of class activities by the teacher to the time when the class was dismissed.

The categorization of the form of interaction was reasonably straight forward in the cases of individual student work and small group activity, although allowance had to be made for the time taken by teacher interventions. This was done by categorizing as whole-class teaching interventions that lasted a minute or more. On the other hand, the distinction between whole-class interactive and whole-class non-interactive teaching is more difficult to make in practice. As a rule of thumb, when the teacher sought and obtained input from students in the form of complete sentences, the teaching was judged to be whole-class interactive. At the other extreme, when there was either no student input or when student response and intervention was limited to single words or phrases, the teaching was judged to be whole-class non-interactive. With this metrestick, the small proportion of didactic teaching in **SciencePlus** classrooms is remarkable. Even more remarkable is the capability of some of the teachers observed to direct class activity without resorting to non-interactive teaching, including procedural matters.

## OCCURRENCE OF SELECTED LEARNING ACTIVITIES

**Table 4. Occurrence of Selected Learning Activities**

| Activity | New Brunswick N | New Brunswick % Class Periods (of 84) | Nova Scotia N | Nova Scotia % Class Periods (of 81) | Total N | Total % Class Periods (of 165) |
|---|---|---|---|---|---|---|
| Hands-on practical work | 21 | 25. | 22 | 27. | 43 | 26. |
| Demonstrations | 18 | 21. | 25 | 31. | 43 | 26. |
| Briefing or debriefing for hands-on work | 10 | 12. | 12 | 15. | 22 | 13. |
| At least one of the above | 41 | 49. | 45 | 56. | 86 | 52. |
| Homework assignments | 37 | 44. | 48 | 59. | 85 | 52. |
| Tests | 5 | 6. | 4 | 5. | 9 | 5. |

N = Number of class periods in which the selected activity occurs

**Comments** Hands-on practical work and demonstrations occur with equal frequency. Altogether, every other 40 minute class period includes either a demonstration or a student hands-on exploration. Homework is assigned with equal frequency.

Because the author did not visit schools during the two weeks prior to the Christmas/New Years holiday and the final three weeks of school, the frequency of testing is somewhat understated. It is still remarkable that no more than one of every 20 class periods observed was the occasion of a quiz or test. This may be one indication of the use **SciencePlus** teachers are making of continuous feedback from students as a means of assessing student progress.

## ATTENTION GIVEN TO SELECTED EDUCATIONAL GOALS

**Table 5. Attention to Selected Educational Goals**

| Goal | New Brunswick | | Nova Scotia | | Total | |
|---|---|---|---|---|---|---|
| | Att'n N (%) | Emphasis N (%) | Att'n N (%) | Emphasis N (%) | Att'n N (%) | Emphasis N (%) |
| Knowledge recall | 29 (35%) | 5 | 16 (20%) | 5 | 45 (27%) | 10 (6%) |
| Concept understand -ing | 70 (83%) | 52 (62%) | 75 (93%) | 56 (69%) | 145 (88%) | 108 (65%) |
| Scientific skills | 40 (48%) | 9 | 56 (69%) | 8 | 96 (58%) | 17 (10%) |
| Communica- tion skills | 44 (52%) | 1 | 41 (51%) | 2 | 85 (52%) | 3 (2%) |
| Social skills | 34 (40%) | 0 | 35 (43%) | 0 | 69 (42%) | 0 |
| Critical thinking & imagina- tion | 48 (57%) | 4 | 39 (48%) | 13 | 87 (53%) | 17 (10%) |
| Interest in further learning | 14 (17%) | 2 | 20 (25%) | 2 | 34 (21%) | 4 (2%) |

N = Number of class periods in which the selected activity occurs

**Comments** Each learning activity observed was categorized according to the educational goals it addressed. The goal which received the major emphasis in each lesson was noted. Goals that were given significant attention or merely attended to were also recorded. This process involved case by case judgement, judgements that might have been made differently by other observers. To address this problem, a criterion for every judgement was that a brief description of the example be provided to corroborate the judgement. All the identified examples are included by category in Appendix I to this report so that the reader might make an independent judgement.

The facilitation of concept understanding was judged to

be the major educational goal in 65% of the class periods observed, a goal that received attention in at least 88% of the class periods. This observation is consistent with the constructivist pedagogy which characterizes the **SciencePlus** curriculum. Nowhere in this curriculum, however, is the short term recall of knowledge emphasized and therefore the content of at least one of each twenty class periods observed was inconsistent with **SciencePlus**.

The attention to scientific skills (58% of class periods) and the engagement of students in critical thinking and imagination (53% of class periods) were likewise consistent with the emphases within the **SciencePlus** curriculum. On the other hand, the infrequent emphasis on the development of interest in further learning (as indicated by instances in which student initiated learning was taking place) suggests a serious weakness in the Atlantic edition of **SciencePlus** and in the way it is being used. Student initiated learning is seldom the focus of learning activities in the units included in the Atlantic edition of **SciencePlus**. It should, therefore, not be surprising that it occurred no more than four times in the 165 class periods observed.

The interchapter features of **SciencePlus**, "Science in Action" and "Science on Your Own", provide abundant ideas and suggestions for student initiated learning. Moreover, most science teachers require participation in projects that the students select and undertake on their own, primarily in connection with science fairs. It is a matter of concern, therefore, that so little class time is given over to student initiated learning activity.

To address this problem, the authors wrote new units for subsequently published editions of **SciencePlus** that include opportunities and encouragement for student initiated learning. If the priority teachers assign to the goal of developing student curiosity and independent learning is to be fully supported, however, there will need to be an even greater change in the curriculum and in teacher's role in the classroom than has yet occurred. Otherwise, student initiated learning in science may continue to be postponed to graduate school (and for most students that means indefinitely!)

## QUALITY OF CLASSROOM LEARNING

**Table 6. Quality of Classroom Learning**

| Form of interaction | Proportion of time (%) | Index of meaningful learning engagement |
|---|---|---|
| Whole-class non-interactive | 12.7 | 2.8 |
| Whole-class interactive | 48.0 | 4.3 |
| Individual student learning activity | 20.6 | 3.9 |
| Small group activity | 18.7 | 4.5 |
| AVERAGE | | 4.1 |

**Comments** The Index of Meaningful Learning Engagement is based on the percent of students at any given time judged by an observer to be engaged in meaningful learning. For this purpose, meaningful learning is judged to occur when students are evidently engaged in concept assimilation and/or use of higher intellectual skills (analysis, synthesis, evaluation, imagination). The following number scale was used:

5 = 90% 4 = 70% 3 = 50% 2 = 30% 1 = 10%

Favourable judgements of student engagement in meaningful learning were based on evidence from overt student behaviour. A running account was made of the proportion of students engaged in learning and what part of the learning activity was meaningful. The product of these two percentages yielded the percentage of meaningful engagement.

Covert behaviour was not necessarily judged to be an indication of non-engagement provided that student interventions in subsequent discussion gave evidence that some meaningful learning was taking place.

Extreme observer judgements were excluded. When there was no evidence of meaningful learning, this observation was recorded as 1 (corresponding to 10% meaningful engagement). On the other hand, even when it appeared that all students were engaged in meaningful learning, this observation was recorded as 5 (corresponding to 90% meaningful engagement).

## COMPARISONS: GRADES 7, 8 & 9 AND FRENCH IMMERSION

**Table 7. Comparisons Between Grades 7, 8, 9 and French Immersion Classes**

| | Grade 7<br>1784 min.<br>46 classes | | Grade 8<br>2197 min.<br>57 classes | | Grade 9<br>2379 min.<br>62 classes | | French Immersion<br>858 min.<br>23 classes | |
|---|---|---|---|---|---|---|---|---|
| Form of Interaction | % | Qual. Index | % | Qual. Index | % | Qual. Index | % | Qual. Index |
| Whole class non int. | 10.2 | 3.1 | 16.0 | 2.3 | 12.0 | 3.0 | 15.7 | 2.2 |
| Whole class interact. | 48.9 | 4.6 | 48.1 | 4.2 | 47.6 | 4.2 | 45.6 | 4.5 |
| Individual learn. act. | 26.3 | 4.0 | 20.9 | 3.8 | 16.9 | 3.7 | 17.9 | 4.6 |
| Small group learn. act. | 14.6 | 4.6 | 15.0 | 4.6 | 23.6 | 4.4 | 20.7 | 4.6 |
| Average | | 4.3 | | 3.9 | | 4.1 | | 4.2 |

**Comments** The difference between the overall average (4.1, or 72%) and the average engagement for a given grade level or for French Immersion is no greater than 0.2 (4%). Differences this small are not considered by the author to be educationally significant. Given the relatively small number of class periods observed, other recorded differences in the quality of engagement for a given form of teaching between grade levels and with French Immersion teaching are not necessarily real differences.

**SMALL GROUP ACTIVITY**

**Table 8. Number and % of Class Periods That Included Small Group Activity**

| | New Brunswick | | Nova Scotia | | Total | |
|---|---|---|---|---|---|---|
| | N | % | N | % | N | % |
| Small Group Activity | 34 | 40% | 25 | 31% | 59 | 36% |
| Small Groups Related to Hands-on Activity | 22 | 26% | 20 | 25% | 42 | 25% |
| Small Groups For Other Assignments | 12 | 14% | 5 | 6% | 17 | 10% |

**Comments** The frequency of small group activity, occurring more than once in every three class periods, is primarily the result of group collaboration in hands-on activity. Otherwise, small group learning is an underutilized strategy by comparison with whole-class teaching, particularly among Nova Scotia teachers. Given that some teachers include small group discussion more frequently, this data indicates that many teachers seldom if ever have students discuss questions in small groups except in connection with hands-on activity.

## LOCATION OF TEACHING & HANDS-ON ACTIVITY

**Table 9. Effect of Location of Teaching**

| | Regular location is a laboratory | Regular location is a classroom |
|---|---|---|
| Number of class periods observed | 52 | 113 |
| Number and percent that included hands-on | 19 (37%) | 25 (22%) |

**Comments** Teachers whose regular location for teaching is a laboratory conduct hands-on activities nearly twice as frequently as those whose regular location is a classroom. In the case of the latter group of teachers, 16 of the classes in which hands-on activity was conducted occurred in the classroom; in the other nine instances, the teacher took the class to an available lab.

## COMPARISON OF OBSERVATIONAL AND SURVEY RESEARCH

**Table 10. Observed and Reported Data**

| | Reported | | Observed | |
|---|---|---|---|---|
| | N.B. | N.S. | N.B. | N.S. |
| Class Size | 24.7 | 24.8 | | |
| Ave. class attendance | | | 23.1 | 20.7 |
| Frequency of demonstrations (number/4 class periods) | 1.1 | 1.1 | 0.8 | 1.1 |
| Frequency of hands-on activities (N/4 class periods) | .9 | 1.1 | 1.0 | 1.2 |
| Frequency of homework assignments (N/4 class periods) | 1.4 | 1.4 | 1.7 | 2.4 |

**Comments** These results confirm the reliability of teacher self-reports. The reported frequencies of demonstrations and hands-on activities (McFadden 1990a, 1990b) match the observed frequencies. The difference between the observed class attendance and the reported class size can be explained by student illness or absence from the classroom for participation in other school events.

Likewise, there is not likely any real discrepancy between the reported and observed frequency of homework assignments. An undetermined number of homework assignments recorded by the observer were assigned by teachers for a longer period than between class meetings and were therefore likely mentioned to students during two or more class periods.

## NON-SCIENCEPLUS TEACHING AND EXEMPLARY SCIENCEPLUS TEACHING

### Non-SciencePlus Teaching Compared to SciencePlus Teaching

In addition to the 165 class periods of **SciencePlus** teaching observed and reported above, four **SciencePlus** teachers were observed while teaching with other student textbooks. Two of these teachers were using old textbooks in some of their classes in anticipation of the introduction of **SciencePlus** the following year. In the case of the other two teachers, one or two units were being taught from previously used student textbooks, while **SciencePlus** was used for most units.

The average level of meaningful student engagement during the four non-**SciencePlus** class periods taught by these teachers was only 2.0 (30%). No practical activity, no small group activity and no attention to scientific skills, other skills, critical thinking or imagination was observed to occur during these lessons. Short term knowledge recall was given more support than long-term understanding of concepts and ideas.

When these four teachers were observed teaching **SciencePlus**, the average level of student engagement was 3.9 (68%), practical activity occurred on 6 of the 9 occasions, understanding rather than recall was emphasized in 7 of the 9 class periods and attention was given on every occasion to scientific skills, other skills or critical thinking and imagination.

### Exemplary SciencePlus Teaching

While the overall quality of the **SciencePlus** teaching observed in New Brunswick and Nova Scotia junior high science classrooms was impressive, much of the teaching witnessed was truly remarkable. The teaching of four of these teachers is indicative of what might be accomplished with proper support for the work of all science teachers at the junior high level.

In the example of these teachers, only once (for four minutes) during seventeen class periods was their whole class teaching non-interactive. This result can largely be attributed to the methods these teachers use to communicate instructions/expectations/information. For example, each of these teachers provides essential information on paper and involves the students in the planning and design of most of the learning activities, ensuring student ownership and engagement.

During the seventeen class periods these teachers were

observed, student hands-on learning activity was incorporated into nine periods and demonstrations were included in another six. Student small group discussion occurred in ten periods, characterized primarily as collaborative rather than merely consultative.

Each of these teachers was observed to take a personal interest in their students. These exemplary grade 7, 8 and 9 science teachers also have the following circumstances in common. They teach only science and each has a significant background in science.

APPENDIX I

**EXAMPLES OF TEACHING STRATEGIES USED BY SCIENCEPLUS TEACHERS**

A summary of the observation of 165 class periods of instruction, distributed among the classrooms of 63 science teachers in 25 randomly selected schools in Nova Scotia and New Brunswick.

**Part I. Nova Scotia summary** (32 teachers in 12 schools, 81 class periods observed)

**Classroom Interaction**

WHOLE CLASS NON-INTERACTIVE (Number of class periods that contained non-interactive whole-class teaching = 40, or 49% of class periods observed)

Brief description of examples observed (with the number of times these examples were observed to occur in brackets):

Related to student hands-on activities:
-Briefing for hands-on activity (7)
-Debriefing of hands-on activity (3)
-Instructions on writing up an exploration (1)
-Distribution of materials (1)

Related to demonstrations:
-Demonstration performed without student input (1)

Related to assigned work:
-Home-work assignment given (11)
-In-class assignment given (5)
-Debriefing of in-class assignment (1)

Related to didactic instruction:
-Information dictated to be copied by students (6)
-Review and tie-in (4)
-Questions dictated to be copied by students (1)

Related to testing:
-Briefing for test (2)
-Tests collected from students (1)
-Tests returned to students (2)
-Lecture on poor student performance (pep talk for test) (1)
-Advice on test taking and test preparation (1)

Organization and management:
-Seating re-organized, attendance taken, other organizational tasks (2)
-Teacher circulated to check that student home assignment completed, without interaction, students not engaged (1)

-Notebooks returned (1)
-Assignment collected, failure of some to complete commented upon (1)

Related to use of audio visual means:
-Briefing for science fair, including 2 videos (one from Nova, the other based on prior local fair), the third in series of classes to stimulate interest and guide participation in science fair (1)
-Film on migration (1)

Announcements:
-Announcement and procedural information related to forthcoming school event (1)

WHOLE CLASS INTERACTIVE (Number of class periods that contained interactive whole class teaching = 63; 78%)

Related to didactic instruction:
-Teacher questions/student answers based on student homework preparation for class or student general knowledge (13)
-Teacher guides students through questions from text (7)
-Individuals read to class passages from text or hand-out (6)
-Teacher questions/student answers based on student prior in class work with textbook material/questions (4)
-Teacher questions/student answers based on posters/diagrams on board as a source of information (3)
-Small groups report results of their deliberations on questions/tasks posed by teacher/text to the class (3)
-Discussion of growth patterns of plants based on student observation of plants that students are growing in classroom "growth center" (1)
-Teacher orchestrated summarization of chemical change through writing word equations (1)

Related to demonstrations:
-Teacher conducted, students assisted exploration/demonstration (8)
-Teacher carried out, students made observations and conclusions in relation to an exploration (4)
-Students guided, individual students conducted exploration/ demonstration (4)
-Students guided, teacher conducted exploration/demonstration (3)
-Teacher guided, individual students conducted exploration/demonstration (2)
-Graphing of data developed through student guided demonstration (1)
-Teacher circulated object for student observation, testing as an illustration of concept or idea (1)

Related to student hands-on activities:
-Debriefing of hands-on exploration (17)

-Briefing for hands-on activity, where students contribute (11)
-Teacher questions/student answers during hands-on activity (2)
-A whole-class hands-on activity (a study of sound reflection in an empty room) (1)

Related to assigned work:
-Debriefing/reviewing/correcting assigned in-class and homework (16)

Related to use of audio visual means:
-Debriefing on film (4)

Related to organization and management:
-Teacher circulated to check that student home assignment completed, interacting with whole class on content of assignment (1)

Related to testing:
-Teacher orchestrated review of teacher constructed study guide in preparation for test (1)
-Debriefing of test (1)

INDIVIDUAL STUDENT WORK (Number of class periods that included individual student learning activity = 40; 49%)

Related to assigned work:
-In-class work on questions/problems from text (15)
-In-class work on teacher generated questions/problems (9)
-Assigned silent reading (4)
-Students read choice of articles and make summary notes (1)

Related to student hands-on activity:
-Write-up of hands-on exploration, with on-going consultation with lab partners (3)
-Conduct of individual hands-on activity (1)
-Write-up of hands-on exploration (1)

Related to demonstrations:
-Write-up of demonstrated exploration (4)

Related to testing:
-Taking a test (5)
-Test correction by reference to listed sources of information (1)

Related to projects:
-In-class work on individual projects (1)

Related to organization and management:
-Teacher allows time at end of period for student social agenda (1)

SMALL GROUP WORK (Number of class periods that included small group work = 25; 31%)

Related to student hands-on activity:
-Collaboration in hands-on exploration (19)
-Discussion/analysis/reflection on prior hands-on exploration (1)
[In hands-on activities, students usually gather and put-away materials; time spent on this is included in this report under the category of "small group work". In general, students were observed to be quick and efficient at this, with established roles and routines.]

Related to assignments:
-Discussion/analysis/problem solving of questions/problems posed by teacher or textbook (4)
-Generation of a technological design solution to problem posed by teacher in preparation for an in-class competition (1)

Size and character of small groups:
*Average size of 2: (7 occurrences, including free choice groups to use a microform viewer, to examine various things under a microscope, to perform chemical tests for sugar, to use the Tyndall effect for determining solutions/non-solutions, to observe and record the locomotion of a worm, and teacher selected groups to examine the evidence and make predictions about the location of earthquakes)
*Average size of 3: (4 occurrences, including free choice, single sex groups to measure temp. over time of ice/water mixture, to determine temperature of water when it freezes, to measure each other's height, head and leg size, to find the effect of hot and cold temperature on the movement of the thumb)
Average size of 4: (8 occurrences, including free choice, single sex groups to deal with questions/problems concerned with developing and applying the concept of pressure, with distinguishing chemical and physical changes, with searching for a relation between mass and volume of a material, with a technological design task involving the concept of buoyancy)
*Average size of 5-6: (1 occurrence, a mixed sex goup, obtained by counting off, for observation and analysis for paper chromatography)
*Average size of 7-8: (1 occurrence, a mixed sex group, for observation and analysis of rock samples)

**Learning Activities**

Demonstrations (25; 31%)
-Teacher conducted demonstration with student input/assistance (15)
-Student guided, student assisted experiment/exploration (5)
-Student guided, teacher conducted experiment (4)
-Teacher guided, student assisted experiment/exploration (1)

Student hands-on practical work (22; 27%)
-Observation and identification of rock types (1)
-Observation of structure of a leaf using microform viewer (1)
-Observation of various objects under microscope (1)
-Observation and identification of parts of a grasshopper (1)
-Test for sugar (1)
-Observation for Tyndall effect (2)
-Paper chromatography (1)
-Determination of melting temperature of water (1)
-Observation of locomotion of worm (1)
-Observation and classification of chemical and physical changes (3)
-Testing of electrical circuits (1)
-Determination of the effect of temperature on thumb movement (1)
-Exploration of the relation between mass and volume for a given material (3)
-Application of the concept of air pressure to a design problem (2)
-Study of human reaction times, comparisons between girls and boys, left hand and right (1)
-Study of sound reflection in a large, empty room (1)

Tests, quizzes (4)

Media use (3)
-Use of videos (NOVA plus local) to stimulate interest in science fairs
-Use of microform viewers - slides
-Video on migration (PBS) and debriefing

Homework assignments (48; 59%)
-Questions from SciencePlus (16)
-Questions developed by teacher (10)
-Write-up of lab activity (9)
-Study for test using review sheets (3)
-Information research project, written report (3, including a project to research one of the scientists who contributed to knowledge of electricity and magnetism, a project to locate and report on a news story related to the environment and a project titled "my solution to pollution")
-Preparation of oral presentation with poster (1)
-Reading assignment from SciencePlus (1)
-Correction of test, based on identification on board of source of information (1)
-Construction of data table to record results (1)
-Preparation for hands-on exploration (1)
-Design of an "animal safe" experiment to determine reaction times in a selected animal (1)
-Assignment to prepare for and give demonstration to the class (1)

Student work on elective projects (assigned, discussed or worked

on in class) (11)

-Science fair project (4)
-Research project, written report (3)
-News stories on environmental theme to be located, put on theme poster and brought to class (1)
-Oral presentation supported by poster (1)
-Home project - test of some product (1)

**Support for Selected Goals**

Recall of Specific Factual Knowledge (14; 17%)

Emphasized (5)
-Emphasis on naming parts of a grasshopper (1)
-Students took test with mainly factual content (2)
-Specific knowledge of location of places, continents (in preparation for study of plate tectonics) (1)
-Taxonomy, with emphasis on memorization of categories and their defining characteristics (1)
Significantly supported (4)
-Content and pace of instruction forces students to rely on memorizing dictated material (1)
-Emphasis on naming parts of leaf and flower at least matched attention to function of named parts (1)
-Students took test with 40% fact recall (1)
-Students drilled on solution facts (1)
Supported somewhat (5)
-Pace of instruction might force students to rely on memorizing dictated statements (2)
-Emphasis on detail might imply expectation that detail be memorized (1)
-Students must know proper symbols for doing circuit diagrams (1)
-Emphasis on spelling of terms (1)

Recall of Formulas, Algorithms (2)

Emphasized (1)
-Recall of formulas and ability to manipulate them, without reflection on underlying concepts (1)
Supported somewhat (1)
-Exercises performed using density formula without reflection on the conceptual content of the exercises (1)

Understanding of Concepts and Relationships (75; 93%)

Emphasized (56; 69%)
-Construction and application of Archimedes Principle (1)
-Saliva converts starch to sugar - hands on exploration including control (1)
-Distinguishing between igneous, metamorphic and sedimentary rocks through hands-on observation, analysis (1)

-Association of parts of leaf with their function (1)
-Application of concept of pressure (1)
-Distinction between solution and non-solution using Tyndall effect (2)
-Directly proportional relation between stretch of spring and applied force (1)
-Distinguishing elements and compounds, reactants and products (1)
-Distinguishing solutions of different composition through paper chromatography (1)
-Melting/freezing takes place at a particular, characteristic temperature (determined in the case of water) (1)
-Emphasis in studying biological classification on learning how the same purpose (for example, reproduction) is accomplished in a variety of different ways (1)
-Student explanation for seasonal variation based on the incline of the earth's axis to the ecliptic (1)
-Distinguishing between pitch, amplitude (loudness) and quality of sound (1)
-Concept of proportion developed by taking relation of head and arm size to total height (1)
-Static electricity concepts: separation of charge, insulators, conductors developed through question/answer drawing from student experience (1)
-Concept of adaptation developed through class discussion (question/answer) of examples illustrated in posters or contributed by students (1)
-Concept of pressure developed/consolidated through small group discussion/solution of questions and problems posed by the teacher (1)
-Chemical and physical changes distinguished (5)
-Construction of food webs and chains (1)
-Concepts developed through hands-on, minds-on exploration and reflection: oxygen given up, carbon dioxide absorbed during photosynthesis (1)
-Through hands-on exploration with a worm and reflection on the observations, students assimilate concept that living things respond to stimuli, both positively and negatively (1)
-Places can be located on a globe knowing their latitude and longitude (a concept developed through application) (1)
-The major concepts in a given unit reviewed through teacher generated questions and quiz and questions and tasks from the text (e.g. Changes in the Land, Current Electricity) (1)
-Application of the concept of air pressure to a technological design problem: How to maintain continuous flow of water through a thin tube into an air-filled flask (4)
-Consolidation, extension of understanding of photosynthesis through application to making sense of scientific articles/reports which assume such understanding (1)
-Through brainstorming a variety of possible causes and guided by teacher questions, students offer gravitational attraction as the likely explanation of the tides (1)

-Concept of reaction time developed through testing (1)
-Concept of electrical resistance assimilated through questions which ask for reflection on (demonstrated) hands-on activity (1)
-Distinction between hibernation and dormancy and concept of tolerance reinforced through questions (1)
-Concepts related to magnetism and static electricity, including the existence of positive and negative charge, the earth's magnetic field and magnetic induction developed/consolidated through debriefing of test questions and reflection on a demonstration (1)
-Concept of force developed through reflection on description of sailing (1)
-Existence of positive and negative charge and a force between them developed through a demonstration, with student analysis (1)
-Concept of sound as a compression wave developed through a demonstration, with student analysis (1)
-The ability of the deaf to locate themselves through sound reflection experienced by students wearing blindfolds and locating themselves through reflected sound (1)
-Students assimilate concept of adaptation by identifying and discussing examples of adaptation to conditions of summer and winter (1)
-Students discuss a variety of specific examples of animal adaptation to winter conditions (1)
-Students reinforce and extend their understanding of natural selection by application to the example of Darwin's finches (1)
-The relation between plate tectonics and volcanic activity analyzed by students in whole-class and small group discussion (1)
-Causes of weathering and erosion considered in relation to local and textbook examples (1)
-The breakdown of white light into a spectrum studied through a series of mini-experiments using two prisms (1)
-Students recognize through a series of experiments that some mixtures are solutions, others are not (1)
-Classification as a kind of directory considered by students in a couple of familiar contexts (phone directory and mailing addresses) and then applied to the classification of living things (1)
-Students explain and apply the concept of diffusion (1)
-Students provide and discuss examples of temperature tolerance of animals (1)

<u>Significantly supported</u> (10)

-Migration and its possible causes discussed (1)
-Attention to functions of parts of flower and leaf received no more than equal billing compared to attention to naming parts (1)
-Some of the questions on a test called for student explanation of the nature of scientific inquiry (1)
-Materials (in this case "mystery powders") can be identified according to their physical and chemical properties (1)
-Students infer the nature of hypothermia from testing the effects of heat and cold on the movement of their thumbs (1)

-Mass increases with volume for a given kind of material (3)
-Discussion of sailing elicits students concepts of force and its effects (1)
-Students worked on questions from textbook that required students to apply their understanding of the concepts solution, solute and solvent, but class discussion tended to emphasize answers as facts to be memorized (1)
Supported somewhat (9)
-Test featured reformulation of concepts/understandings as a significant but not the major component (2)
-Use of compare and contrast during process of identifying parts of a grasshopper (1)
-Concept embedded in learning activity, but no teacher-directed reflection on concept (3)
-Concepts of softness, strength, absorbency as a byproduct of student guided, teacher conducted experiment to illustrate identification and control of variables in experimentation (1)
-Identification of factors that may be involved (1)
-Some attention to plant processes in context of defining taxonomic categories for memorization (1)

Scientific experimental skills (22; 27%)
Emphasized (5)
-For mystery event (puddle of water on the floor), students provide observations, inferences, predictions and testable hypotheses, and distinguish between each of these component processes (see DIME) (1)
-In testing to identify mystery powders, students formulate the problem, hypotheses, procedures, observations and conclusions (1)
-Students assist in planning an experiment on the effects of heat and cold on the movement of their thumbs and, as part of their write-up, plan an experiment to test the tolerance of a dog to heat (1)
-Students identify the uncontrolled variables and sources of error in an exploration of the relation between mass and volume for a given material (1)
-Students design an experiment (1)
Significantly supported (5)
-Students assist in experimental design (1)
-Students make predictions, guide teacher testing and offer explanations for variation of pitch (1)
-Students identify variables that may be involved in plant growth (1)
-Students respond to test questions concerned with the nature of scientific inquiry and the distinction between fact and inference (1)
-Students classify examples (1)
Supported somewhat (12)
-Teacher points out the use of a control in a teacher or textbook author designed experiment (4)
-Teacher identifies factors that could interfere with veracity of Tyndall effect (2)

-Teacher cites examples from student science fair projects of the control of variables in experimentation (1)
-Students hypothesize relationship between mass and volume for a given kind of material (1)
-Students engage in problem solving design and testing, but without explicitly identifying the factors/variables that might lead to and explain success and failure (4)

Ability to interpret and construct tables and graphs (7)
Emphasized (1)
-Student constructed and interpreted tables and graphs of temperature versus time in an ice plus water mixture (1)
Significantly supported (4)
-Student constructed graph (1)
-Students assist in designing table for recording their data (2)
-Students assist in designing graph for displaying their results (1)
Supported somewhat (2)
-Student guided, teacher constructed table, graph or bar graph (2)

Skill at observing, measuring, recording (27)
Emphasized (2)
-Observation, sketches, comparisons of various objects under a microscope (1)
-Observation, recording (through sketches) of paper chromatography as a means of distinguishing inks from various sources (1)
Significantly supported (14)
-Observation including analysis/categorization as central feature of hands-on exploration (4)
-Observation including analysis/categorization based on illustrations in the textbook (1)
-Observation and drawing of parts from viewing prepared slide (1)
-Classification through photo interpretation (2)
-A series of measurements with attention to round-off (1)
-Observations, sketches to determine method of locomotion (1)
-Measurement activity with focused attention on techniques, accuracy or precision (1)
-Observation of the tests of various proposed solutions to a technological design problem in order to come up with proposals that might work and explain those that do work, including attention to the distinction between observation and inference (3)
Supported somewhat (11)
-Highly guided observation (identification of parts of frog) (1)
-Observation, measurement and recording associated with hands-on explorations (for example, observation of results of chemical test, observation of Tyndall effect, observation, measurement and recording of ice melting in an ice-water mixture, measurement of extension using metrestick, measurements of time, temperature, mass and volume) (9)

-Observation and recording based on samples circulated around the class (1)

Skills of written and oral communication (35; 43%)
Significantly supported (19)
-Shared understanding/meaning constructed primarily through student oral contributions (7)
-Student understanding/meaning constructed through small group discussion and individual writing (2)
-Sentence and paragraph responses required to questions on a test (1)
-Given the objective of testing "mystery powders" students formulated orally and then in writing their own hypotheses, procedures, observations and conclusions (1)
-In connection with hands-on exploration: students write full paragraph observations, conclusions in their own words (8)

Supported somewhat (16)
-In connection with hands-on exploration: full sentence writing in own words (6)
-In response to questions from the text, students provide written answers (full sentences) in their own words (2)
-Preparation for oral presentation (1)
-Student interventions in whole class discussion - complete (full-sentence, not words/phrases) thoughts (their own) (5)
-Test required students to respond with complete thoughts in their own words (2)

Reading skills (6)
Emphasized (2)
-Reading scientific articles for meaning (summarization in own words required) as an enrichment activity in relation to concepts assimilated in prior learning (1)
-In a class of students functioning with well-below grade-level reading skills, each student reads out sentences or paragraphs from high interest, adult level reading material (The Winter of the Fisher) and then participates in a class discussion based on the material read (1)
Significantly supported (1)
-Reading comprehension developed through use of a supplemental science reader with content questions. (1)
Supported somewhat (3)
-Several individual students called upon to read passages from text out loud (3)

Understanding of science as a human social activity conducted in a societal and historical context (0)

Understanding of technology and its relation to science (6)
Significantly supported (1)
-Guided by selected reading materials, students apply their knowledge of photosynthesis to the design of technology that

might profitably utilize this knowledge (1)
Supported somewhat (5)
-The development of such understanding may be implicit in the instances in which students engage in designing solutions to technological problems in association with the construction/ consolidation/ application of scientific concepts (5, four of these instances in one teacher's classes)

Informed participation in democratic decision making on science related social issues (0)

Critical thinking skills (25; 31%)
Emphasized (5)
-Students develop proportional reasoning skills through measurement and comparison of head and arm length to total height (1)
-Students assist in the planning and carrying out of an experiment and, as a follow-up, design another experiment that also requires identification and control of variables (1)
-Students design an experiment on the relation between mass and volume through whole class discussion, carry it out in small groups, and as a class share their results and suggest sources of error (2)
-Students develop classification systems in a variety of contexts (grocery store, living things) (1)
Significantly supported (11)
-Students guide, analyze results of teacher conducted experiment involving identification and control of variables (1)
-Students undertake an analysis and categorization of their observations, proceding to formulation of testable explanatory hypotheses (1)
-Students analyze living things, categorizing them according to how a given function is performed (1)
-Students classify objects according to attributes they have selected (1)
-Students analyze and complete/correct incomplete/incorrect food webs and chains (1)
-Students identify forces and their effects in connection with sailing (1)
-Students engage in problem solving design that involves application of or explication through scientific concepts (3)
-Students design an experiment to test reaction times (1)
-Students examine illustrations of the beaks of Darwin's finches and relate this evidence to the theory of natural selection (1)
Supported somewhat (9)
-Students analyze sound to determine various categories to be used in describing variation in sound (1)
-Students identify area as a variable contained by the concept pressure as force as variables involved (1)
-Students categorize observed changes into physical or chemical according to agreed upon rules (4)
-Students distinguish examples of observation and inference (1)

-Students analyze their recorded observations and data to identify several "mystery powders" (1)
-Students distinguish between examples of solutions and non-solutions (1)

Curiosity, interest in further learning (20; 25%)
Emphasized (2)
-Interest in science fair projects stimulated by presentation (videos) of student work, with discussion (1)
-Tasks assigned for independent investigation and report-back to class as a regular, on-going feature of class activity (1)
Significantly supported (5)
-Science fair projects required (1)
-Meaning constructed by drawing heavily on students' experiences, with evidence of high level of student engagement and interest in the learning activity and its relation to their life experiences (4)
Somewhat supported (13)
-Topics of required home projects selected by students from list or within theme provided by teacher (2)
-Students invited to bring things from home to view under microscope (1)
-Students encouraged to carry on at home an in-class activity in which they are highly engaged (1)
-Students encouraged to do some advance thinking about their science fair projects in preparation for brainstorming next class (1)
-Hands-on exploration centred on self, for example, a study of the effects of heat and cold on the movement of student's thumb (1)
-Students apply concepts being studied to the solution of a technological design task (3)
-Students design own experiments to test animal reaction times (1)
-Students to prepare demonstrations to perform next day in class (1)
-Students encouraged to try out some optional experiments at home and report back (1)
-Students undertook an information search to locate volcanic sites on a map (1)

NB: In addition to the above, classroom interaction frequently featured examples provided by students from their everyday experience, a practice which is thought to stimulate curiosity and interest in further learning. This practice occurred so often that no systematic record of examples was kept.

Imagination and creativity (14; 17%)
Emphasized (8)
-Students design experiment (1)
-Students plan, carry out and interpret results of an experiment

(5)
-Students propose and test their own solutions to a technological design problem (1)
-Students develop classification system for a grocery store as an extension of a series of classification activities (1)
Significantly supported (4)
-Students assist in the design of an experiment and, as home assignment, design their own experiment (2)
-Students devise own classification system (1)
-Students collaborate in small groups to plan their own solution to a technological design problem (1)
Somewhat supported (2)
-Examples cited (supported by video) of imagination used by students in design/selection of science fair projects (1)
-Original to the student solutions to the task of identifying mystery powders without tasting or smelling them (1)

Interpersonal skills (35; 43%)
Significantly supported (11)
-The construction of meaning through small group discussion as the major intended activity rather than a collateral benefit of incidental sharing of understanding during a learning activity undertaken in small groups (4)
-Collaboration in small group hands-on activity with attention given by the group to designing, planning, recording, reporting and/or interpreting (7)
Somewhat supported (24)
-Participation/collaboration in small group in connection with hands-on exploration (15)
-Participation/collaboration in small group discussion of questions posed by teacher or textbook (3)
-Independent work characterized by frequent consultation (2)
-Whole class collaboration in technological problem solving (with underlying scientific concept involved) (3)
-Small group collaboration in technological problem solving (1)

Other (1)
Emphasized (1)
Skill of using a microscope (1)

**Part II. New Brunswick summary** (31 teachers in 13 schools, 84 class periods observed)

**Classroom Interaction**

WHOLE CLASS NON-INTERACTIVE (Number of class periods that contained non-interactive whole class teaching = 47, or 56% of class periods observed)

Brief description of examples observed (with the number of times these examples were observed to occur in brackets):

Related to student hands-on activities:
-Briefing for hands-on activity (12)
-Debriefing of hands-on activity (1)

Related to assigned work:
-Briefing given for home-work assignment (1)
-Home-work assignment given (6)
-In-class assignment given/explained (8)

Related to didactic instruction:
-Information dictated on board, copied by students (3)
-Information read to class from teachers resource book (1)
-Information read to class from student text (1)
-Student write-up read out by teacher to class (1)
-Tie-in with previous days's work (1)
-Tie-in with next day's work (1)
-Procedural information given related to student presentations in class (1)
-Student presentations are largely non-interactive (1)

Related to testing:
-Test questions copied from board (1)
-Briefing for a test (2)
-Debriefing of test (2)

Organization and management:
-Students advised about division of labour within small groups (1)
-Caution given about lab behaviour (1)
-End of class given over to students social agendas (2)
-Marking procedures explained (1)

-Attendance taken (2)
-Problem of class behaviour addressed (1)
-Handing out and collection of assigned work (3)
-Reminder given about neatness in writing up assignments (1)
-Teacher checked homework/notebooks (5)

Related to the use of audio-visual means:

-Film on erosion (1)

Announcements:
-Announcements from school office (1)
-Announcement by teacher of public lecture on science (1)

WHOLE CLASS INTERACTIVE (Number of class periods that contained interactive whole class teaching = 64, 76%)

Related to didactic instruction:
-Teacher questions/student answers based on student homework preparation for class or student general knowledge (22)
-Teacher guided students through questions from text (3)
-Individuals read to class passages from text (1)
-Individual students read paragraphs from text and provide a title for paragraph (1)
-Debriefing from small group discussion (1)
-Teacher guided students through graphing of data and interpretation of resulting graphs (2)
-Student oral presentations engaged some student response and interaction (1)

Related to demonstrations:
-Demonstration by teacher (10)
-Student assisted demonstration (4)
-Students demonstrated their designs (1)

Related to student hands-on activities:
-Pre-lab discussion, briefing (10)
-Debriefing of hands-on exploration (17)

Related to assigned work:
-Debriefing/reviewing/correcting assigned in-class and homework (18)
-Guidance to students' conduct of practical activity (1)
-Students show the creatures they have designed and explain the adaptive advantages of this and that feature they have given their creatures (1)

Related to testing:
-Review for test (1)
-Debriefing of test (2)
-Debriefing of quiz (1)

INDIVIDUAL STUDENT WORK (Number of class periods that included individual student learning activity = 40; 48%)

Related to assigned work:
-In-class work on questions/problems from text (16)
-Students construct and interpret graphs from given data (2)
-In-class work on teacher generated questions/problems/tasks (9)
-Students read material from text (1)

Related to student hands-on activity:
-Setting up lab book to record data and observations (1)
-Completing lab write-up (2)
-Graphing data obtained by various groups (1)
-After observing a procedure, students practiced it themselves (1)

Related to testing:
-Review for a test (2)
-Taking a test (5)

Related to projects:
-Students worked on plans for science fair projects (1)
-Students worked on an environmental project (1)

SMALL GROUP WORK (Number of class periods that included small group work = 34; 40%)

Related to student hands-on activity:
-Collaboration in hands-on activity (21)
-Students make prediction of expected outcome of exploration (1)

Related to assignments:
-Discussion/analysis/problem solving of questions/problems posed by teacher or textbook (10)
-Students collaborate on a research project (2)

Size and character of small groups:
*Average size of 2: 3 occurrences of free choice groups to discuss questions from text; 5 occurrences of free choice groups for hands-on practical work; 2 occurrences of free choice groups to plan or work on research project; 1 occurrence of teacher selected groups for discussing problems from text
*Average size of 3: 1 occurrence of free choice groups to discuss questions from text; 1 occurrence of free choice groups collaborating on library information search; 7 occurrence of free choice groups for hands-on practical work; 4 occurrences of teacher selected, mixed sex groups for hands-on practical work, including making predictions, exploration of why boats float, making straw hydrometers; 2 occurrences of teacher selected mixed sex groups to discuss questions from text
*Average size of 4: 2 occurrences of free choice groups to discuss questions from text; 2 occurrences of free choice groups for hands-on practical work; 3 occurrences of teacher selected groups for hands-on practical work; 1 occurrence of teacher selected groups to discuss questions from text

**Learning Activities**

Demonstrations (18)
-Students demonstrate their balloon driven vehicles

-Teacher demonstration of convection in a beaker heated from below
-Teacher demonstration of convection in the air above a candle
-Student assisted demonstration of evidence for the existence of particles
-Teacher exhibits and passes around various sedimentary rock types
-Identification of three liquids using hydrometer
-Demonstration of an experimental procedure (4)
-Demonstration of the presence of starch
-Use of equal arm balance for determining mass
-Method of measuring height
-Air pressure change associated with talking
-Student assisted location of images using demonstration size mirrors (2)
-Student assisted demonstration of osmosis
-Demonstration of a procedure: simulation of coriolus effect

Student hands-on practical work (21; 25%)
-Exploration of surface tension
-Exploration of heat conduction
-Exploration of effect of buoyancy of water on apparent weight of object
-Measurement of buoyant force
-A series of explorations related to particle theory (2)
-Exploration of why boats float (3)
-Making of straw hydrometer (2)
-Indirect measurement of height
-Study of osmosis through permeable membrane
-Portion of shell of egg removed, leaving membrane (4)
-Study of electrostatic forces
-Study of coriolis forces (3)

Tests, quizzes (5)

Media use (1)
-Film on erosion

Homework assignments (37; 44%)
-Preparation for hands-on exploration
-Questions from SciencePlus (19)
-Questions, tasks set by teacher (7)
-Completion of write-up of hands-on exploration (3)
-Do hands-on exploration at home (3)
-Information research project (2)
-Outline for science fair project
-Assigned to read Science In Action feature

Student work on elective projects (assigned, discussed or worked on in class) (8)
-Student presentations of their project work (2)
-Students wrote up their plans for science fair projects

-Project assigned (2)
-Students plan project
-Students work on project
-Library information search and write up of main points

**Support for Selected Goals**

Recall of Specific Factual Knowledge (25; 30%)

Emphasized (4)
-Definitions of geographical terms
-Naming of rock types
-Definitions of endothermic, exothermic, compounds, molecules and atoms stressed by teacher
-Students identify information from periodic table and construct atomic models, but without an understanding of the basis for the model (as evident in the failure to recognize that atomic weights reflect the occurrence of various isotopes of a given element)
Significantly supported (11)
-Review for exam included informational content of unit
-Student oral presentations emphasize factual information
-A significant emphasis of film was on naming of features and kinds of erosion
-Students spent about half of class period copying definitions from board (3)
-Students complete crossword puzzle and fill-in-the-blank questions
-Quiz featured recall of information given on previous day
-Review by teacher of true/false and multiple choice responses on test focused on correct answers with little conceptual elaboration
-Teacher places stress on informational content of discussion
-Teacher emphasized definitions and formulas
Supported somewhat (10)
-Knowledge expected by teacher of appropriate tests for presence of carbon dioxide and starch
-Knowledge of pH values of specific substances emphasized
-Characteristics of taxonomic groups defined
-Definitions of mass and weight given
-Knowledge of safety rules tested
-Students completed one fill-in-the-blank question
-Biological classification - recall of examples stressed
-Attention to procedural knowledge for ray tracing (2)
-Functions of thyroid, pancreas and role of ATP to store energy probably assimilated by students as information to memorize rather than understood

Recall of Formulas, Algorithms (3)

Emphasized (1)
-The main emphasis of lesson was on the recall of formulas and the correct substitution of quantities in these formulas

Supported somewhat (2)
-Balanced chemical equations copied from board
-Equation for density

Recall of Relationships (2)

Somewhat supported (2)
-The statement by the teacher of Archimedes principle was emphasized during briefing for practical activity
-The teacher emphasized the generalization of a series of demonstration: heat rises

Understanding of Concepts and Relationships (70; 83%)

Emphasized (52)
-In small groups, students discussed questions related to the process of photosynthesis
-Students applied particle theory to explain their observation of surface tension supporting a needle floating on water
-Students distinguished mass and weight through explanation of several problem situations
-Students developed an understanding of the process of convection through observation, generalization and application of the observed results of teacher demonstrations
-Students develop understanding of the role of models in scientific explanation through discussion of examples and application of particle theory to explain experimental observations
-Students explored and identified dependence of heat conduction on kind of material and other variables
-Students identify chemicals as constituents of materials and commercial products
-Students answer questions from text regarding formation and nature of acid rain
-Students apply their understanding of interdependence of living things to research projects on environmental problems
-Students answer a series of questions in writing related to adaptation
-Students develop an explanation for why boats float through a guided hands-on inquiry
-Students apply concept of gravitational attraction to writing fictional story of effects of anti-gravity spray
-Students individually and in whole-class debriefing identify stages of human growth and apply concept of proportion in relating sizes of head to total height at various ages
-Students discuss and predict the expected outcomes for a series of explorations they will do concerned with diffusion and osmosis
-Students use hydrometer to determine relative densities of liquids
-Students assimilate concept of buoyant force through a series of explorations that include the measurement of this force
-Students answer review questions on floating and sinking which

require reformulation and application of concepts of buoyancy and density
-Students answer review questions on interactions which require reformulation and application of ecological concepts
-Questions on a test require application and reformulation in students own words
-Most of the questions asked in review of units on living things and nature of science required students to formulate their understanding in their own words
-Students apply concept of air pressure to explain action of pumps and syringes
-The flow of wind from high to low pressure regions and the effects on wind direction of coriolus forces studied through a hands-on simulation
-The presence of two kinds of electric charge and the forces between charged bodies studied through reflection on hands-on exploration
-Students develop understanding of tolerance through practical exploration of the tolerance of sow bugs to light and smell and reflection on their observations
-Students apply particle theory to explain states of matter and behaviour of matter
-Understanding of functioning of a voltaic cell achieved by students in part through a reflective reading task (assigning titles to paragraphs) and small group discussion of related questions
-Students assimilate concept of photosynthesis through a variety of learning activities
-Concepts of stored energy and controls in body functions assimilated by students through analogies presented by teacher and follow-up research projects by students
-Concept of acidity and pH scale applied by students in discussion of acid rain and methods of counteracting its effects (2)
-Concepts of diffusion and osmosis assimilated through explorations using dialysis tubing, concentrated sugar solution, starch and iodine
-Students assimilate concepts related to images formed by mirrors and lenses by ray tracing and through whole class discussion (2)
-Students assimilate concept of density as slope on a graph of mass over volume through constructing and interpreting graphs for different materials
-Students construct concept of density as a relationship between mass and volume through reflection on a number of examples, questions
-Students consolidate concept of density through construction and interpretation of graphs
-Students predict and explain why some objects float and others sink
-Students explore why boats float, develop concept of buoyancy through reflection on exploration (2)
-Students identify examples of biotic and abiotic relationships

-Students answer questions about erosional processes, causes of erosion
-Students complete "brain teasers" related to chemical and physical changes
-Students reflect on the operation of the straw hydrometers they have made, applying the concept of density to their explanations
-Students construct and explain food webs (2)
-Students discuss distinctions between mass and weight and compounds and mixtures
-Students described examples of generation of electricity and responded to questions about current electricity concepts
-Testing through application for various concepts related to floating and sinking
-Testing through application for various concepts from the units on interactions and chemical changes
-Testing through application for various concepts from the units on living things and solutions

Significantly supported (12)
-Students respond to questions about natural selection and provide examples of adaptation
-The rotation of the earth about its axis described by students, including location of axis, longitude and latitude lines
-Attention in whole class discussion to processes by which various sedimentary rock types were formed, including sketch by students of formation of a delta at mouth of river
-Students apply solutions concepts to study of pollution and means of dealing with it
-Students present the creatures they have designed and explain the adaptive advantages they have given them
-Students applied particle theory to explain observations of diffusion, contraction of a balloon when placed in a refrigerator, rapid evaporation from a heated surface etc. (2)
-Some student oral presentations to class emphasize how pollution of various kinds is caused and how it can be dealt with
-Students discuss graphical relation between solubility and temperature
-Students identify from a story the included examples of chemical and physical changes
-Students distinguish examples of observations and inferences

Supported somewhat (6)
-Teacher leads whole class discussion of regrigeration
-Some attention drawn by teacher to concept of osmosis, in anticipation of hands-on activity to follow next day (2)
-Students prepare for an exploration of solutions and non-solutions
-Students spent minor part of class period on question concerned with tectonic processes
-Students give some attention to inference of particle nature of matter from examination of electron micrograph

Scientific experimental skills (12)

Significantly supported (5)
-Students formulated hypotheses, designed and carried out experiments to test them (3)
-Students formulated hypotheses (2)
Supported somewhat (7)
-Stress placed in whole-class debriefing of hands-on activity of the importance of the control used
-Students identified variables that might affect heat conduction
-Attention drawn by teacher to control of variables (mass) in exploration of why boats float
-Students identify sources of error in exploration on why boats float
-Students make predictions of expected outcomes (2)
-Students relate graphed results to their initial predictions

Ability to interpret and construct tables and graphs (9)

Emphasized (5)
-Students graph their experimental data relating mass and speed and interpret the result
-Students construct and discuss graphical relationship between mass and volume for various substances (2)
-Students construct and discuss graphical relationship between solubility and temperature
-Students interpret periodic table of the elements
Significantly supported (2)
-One quarter of the value of a test assigned to interpretation of tables and graphs
-Students spend a major part of period interpreting histograms
Supported somewhat (2)
-One question on test required interpretation of a table and completion of a histogram
-Student correction, interpretation of graph of experimental data

Skill at observing, measuring, recording (19)

Emphasized (4)
-Students identify numerous examples distinguishing observation and inference
-Students calibrate and use their own straw hydrometers (2)
-Indirect measurement of height
Significantly supported (9)
-Students use graduated cylinder for volume measurements
-Spring scale used for a series of measurements - attention given to checking zero point on scale
-Observation and interpretation of relationships from photographs as a major part of learning activity
-Observation, measuring and recording in a hands-on exploration to test a prediction
-Observation, measuring and recording in an exploration of variables that affect heat conduction
-Observation in a series of hands on explorations to test

hypotheses students have formulated
-Students tested for ability to distinguish observation and inference
-Careful observation and explanation of observations stressed (2)
Supported somewhat (6)
-Observations distinguished from inferences
-Observations the basis for description and explanation of a process (5)

Skills of written and oral communication (42; 50%)

Emphasized (1)
-Class features student oral presentations on various aspects of pollution
Significantly supported (19)
-Students individually provided written responses to questions based on small group discussion
-Shared understanding/meaning constructed primarily through student oral contributions (3)
-Most of the value of a test assigned to questions that required students to express ideas in their own words (4)
-Students engaged for major part of class period in answering questions in writing using their own words (5)
-Students formulate in writing their own hypotheses, observations and conclusions in connection with a hands-on exploration
-Students formulate in writing their observations and explanations (2)
-Students write fictional story about effects of anti-gravity spray
-Students spend class period writing on environmental issues they have researched
-Students write stories that include references to chemicals
Supported somewhat (22)
-In response to questions from the text or teacher, students provide written answers (full sentences) in their own words (10)
-Student interventions in whole class discussion - complete (full-sentence, not words/phrases) thoughts (their own) (12)

Reading skills (2)

Significantly supported (1)
-In class information research project focused on extraction of needed information from a variety of references
Supported somewhat (1)
-Students title paragraphs to represent the main meaning of the material read

Understanding of science as a human social activity conducted in a societal and historical context (0)

Understanding of technology and its relation to science (1)

Supported somewhat (1)
-Students design cars propelled by a balloon as project associated with the study of forces and motion

Informed participation in democratic decision making on science related social issues (6)

Emphasized (1)
-Students worked on posters and papers to inform the public on environmental issues (for public display)
Significantly supported (2)
-Students made oral presentations to class on pollution and its causes and proposed solutions
-Students engaged in library research project and class discussion of pollution including design of ways to address pollution problems
Supported somewhat (3)
-Students working on publicity for a public environmental project
-Class discussion of local examples of sources of acid rain
-Class discussion of effects of DDT in the food chain

Critical thinking skills (37; 44%)

Significantly supported (12)
-Students designed, built and explained the forces acting on balloon driven model cars
-Students evaluated the adequacy of various scientific models
-Concept of air pressure applied by students to explain functioning of a pump and a syringe
-Through specific examples students analyze relations between mass, volume, density and buoyancy (2)
-Students engaged in prediction and reasoned explanations throughout class period (2)
-Students use proportional reasoning to construct and calibrate their own straw hydrometers (2)
-Students distinguish between observation and inference
-Students engaged in formulation, testing and confirmation/rejection of their own hypotheses
-Students engaged in explaining the effects of coriolus forces on wind direction through analysis of a simulation
Supported somewhat (15)
-Students identify variables that might affect heat conduction
-Students make evaluative judgements in doing projects on environmental issues
-Proportional reasoning required for interpretation of histograms
-Students made proposals for dealing with pollution problems xx
-Students required to apply particle theory to create unusual definitions distinguishing solids, liquids and gases
-Several of the questions on a test on solutions required analysis
-Students analyze examples of different kinds of biotic and abiotic relationships

-Students distinguish chemical from physical changes
-Students construct food webs, categorize relationships into herbivore, carnivore, omnivore (2)
-Students infer process of diffusion through permeable membrane as explanation for observations
-Students involved in teacher guided design of experimental set-up (2)
-Students categorize liquids according to density and predict readings they will obtain with hydrometer

Curiosity, interest in further learning (14)

Emphasized (2)
-Students in groups of two select and work on own projects
-Students in small groups engage in library research on various forms of pollution, share results and propose solutions to pollution problems
Significantly supported (7)
-Students selected, carried out research and developed papers and posters for public display on environmental issues
-Several student overheard to be planning their own at home extension of in-class hands-on exploration
-Meaning constructed by drawing heavily on students' experiences, with evidence of high level of student engagement and interest in the learning activity and its relation to their life experiences
-Students present results of independent project activity they have completed (2)
-Students develop plans for science fair projects
-Students engaged in guiding and correcting teaching and text
Somewhat supported (5)
-Elective project on design, construction and testing of balloon driven car
-Exploration assigned as a home task
-Students initiate questioning, propose and carry out experimental tests of their ideas
-Project assigned
-Students called upon frequently to provide examples familiar to them

Imagination and creativity (11)

Emphasized (4)
-Students designed, built, tested and explained balloon driven model cars
-Students each designed a creature and explained the adaptive advantages they have given to their creatures
-Students designed experimental set-up to test their own hypotheses and carried out test
-Students designed logos to go on T-shirts to publicize environmental campaign
Significantly supported (2)
-Students used imagination to advertise their concerns about

environmental issues via publicly displayed posters
-Students write fictional account about effects of anti-gravity spray
Somewhat supported (5)
-Students propose possible solutions to some of the pollution problems they have identified
-Students construct (draw) their own models of the functioning of a food dispensing machine
-Students involved by teacher in design of experimental set-up (2)
-Students provide analogies for particle movement based on every-day events

Interpersonal skills (34; 40%)

Significantly supported (17)
-The construction of meaning through small group discussion as the major intended activity rather than a collateral benefit of incidental sharing of understanding during a learning activity undertaken in small groups (11)
-Students collaborate in the design and execution of an experiment
-Students collaborated in the design, construction and testing of a vehicle
-Students collaborate in the selection and carrying out of a research project (4)
Somewhat supported (17)
-Learning activity includes some small group consultation/collaboration (14)
-Rules and procedures for collaboration in small groups established by teacher
-Independent work characterized by frequent consultation (2)